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EVALUATION OF DIMETHYL AND METHYL ANTHRANILATE AS A CANADA GOOSE REPELLENT ON GRASS

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Canada goose (*Branta canadensis*) populations are increasing in many areas of the United States (Williams and Bishop 1990), resulting in increased damage to sprouting and ripening crops, and nuisance problems in and near urban areas (Hunt 1984, Knittle and Porter 1988) associated with geese foraging on grass in landscaped areas, parks, backyards, and golf courses (Hawkins 1970, Laycock 1982). In addition, feces left by geese reduce the aesthetic value and recreational use of these areas and negatively impact water quality and public health (Conover and Chasko 1985).

Management of nuisance goose populations usually involves the use of pyrotechnic devices, traps, and mechanical scare devices (USDA

1986). However, use of these techniques is often limited by costs, logistics, effectiveness, or a combination of these factors. These limitations have stimulated efforts to develop chemical repellents that are effective and economical, but also safe to target and nontarget species. Dimethyl anthranilate (DMA) and methyl anthranilate (MA) are two promising candidates that are unpalatable and aversive (odor) to birds (Mason et al. 1989). Both chemicals are registered with the Food and Drug Administration (FDA) as human-safe food flavorings. DMA has been successfully tested as a bird repellent when added to livestock feed (Mason et al. 1985, Glahn et al. 1989), and laboratory tests have suggested that MA is as effective as DMA (Mason et al. 1989).

In a preliminary demonstration at a 1.2-ha site at Foothills Golf Course near Lakewood, Colorado, DMA (14%) in a time-release waterproof starch matrix was sprayed at a rate of 3.4 kg/ha active ingredient (A.I.) (J. L. Cummings, unpubl. data). Observations during a 10-day pretreatment and 19-day post-treatment period indicated a 96% decrease in presence of geese and an 84% reduction in fecal deposits. The promising results of this demonstration prompted us to evaluate the efficacy of DMA and MA to reduce goose grazing on grass.

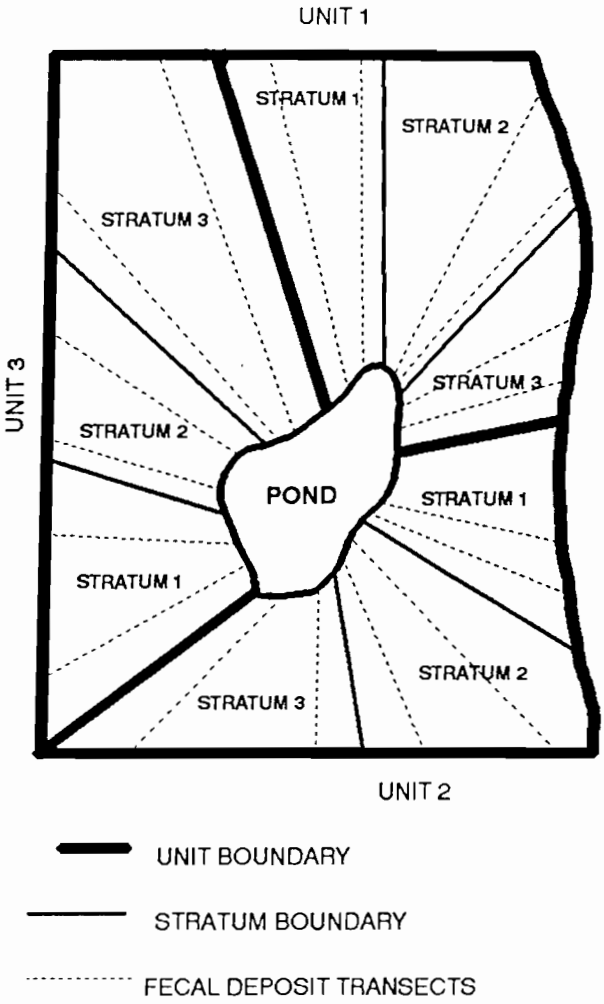

Fig. 1. A representative study site layout for testing dimethyl anthranilate (DMA), methyl anthranilate (MA), and control treatments to repel geese from grazing during June and July 1988 near Basking Ridge, New Jersey.

STUDY AREA AND METHODS

The study was conducted at 5 sites near Basking Ridge and Princeton, New Jersey, during June and July 1988. All sites were located at corporation headquarters except one which was at a golf course. Sites were planted in Kentucky blue grass (*Poa pratensis*) and ranged in size from 1.8 to 7.0 hectares. Generally, sites were areas of similarly maintained grass with very little human activity, except at the golf course. Because of the timing of this test (during gosling rearing and molt) geese were restricted to test sites for feeding. At the center of each site was a pond (range: 0.4 to 4 ha) (Fig. 1). Each site was separated from the others by at least 8 km and had resident populations of Canada geese. No form of goose control or artificial feeding program was conducted at any of the sites during the course of the study.

We divided each site into 3 experimental units of equal (in one case, near equal) size that bordered a pond, and randomly assigned to each DMA, MA, or sham (control) treatment (Table 1). Units were identified by marking their corners and a point midway between each corner with colored 1.5-m survey stakes 7 days before the day of treatment. National Starch and Chemical Co. (NSC), Bridgewater, New Jersey, encapsulated both DMA and MA at a 20 and 20.5% concentration, respectively, in a starch matrix to reduce chemical volatility and photodegradation. The starch matrix was screened to produce particles between 50 to 80 mesh size. DMA or MA material was formulated with 85% water and 15% casein sticker. We verified anthranilate concentrations in the starch matrix by gas chromatography (R. Trksak, NSC, pers. commun.) prior to shipment, mixing, and spraying.

We sprayed each unit chosen for treatment with

Table 1. Treatment date, size (ha), and assigned treatment for experimental units at each of 5 sites used to evaluate dimethyl anthranilate (DMA) and methyl anthranilate (MA) during June and July 1988 near Basking Ridge, New Jersey.

Site	Date treated	Units 1 Size	1 Treatment	2 Size	2 Treatment	3 Size	3 Treatment
AT&T	11 Jun	1.0	Control	1.0	MA	1.0	DMA
Johnson & Johnson	12 Jun	1.7	MA	1.7	Control	1.7	DMA
Allied	15 Jun	1.3	MA	1.3	DMA	1.3	Control
Bell	11 Jun	0.4	DMA	0.4	Control	0.6	MA
Summit	13 Jun	1.0	MA	1.0	DMA	1.0	Control

DMA or MA 1 time at 3.4 kg (A.I.) per hectare with a boom-type Nifty sprayer (Rears Mfg. Co., Eugene, Oreg.) pulled by a 4-wheel all-terrain vehicle (ATV). Booms were fitted with Tee Jet® flat fan nozzles (Spraying Systems, Wheaton, Ill.) and calibrated to deliver 308 L/ha at 275 kilopascal (kpa) and at 8 km/hour. Calibration of spraying apparatus was made pre- and post-treatment following methods described by O'Neal et al. (1984). The same equipment was used for all applications. We sprayed control units first with the formulation (minus DMA or MA) at the same application rate to prevent any possible contamination from the treated formulation; all equipment was thoroughly cleaned after each application.

To determine the amount of fecal deposits at each site, we divided units into 3 strata of near equal width. Each stratum bordered the pond. Within each stratum, we randomly located 2 transects perpendicular to the pond and extending the length of the stratum. Transects varied from 4 to 134 m due to irregularly shaped experimental units and were marked at 6-m intervals with a spot of orange spray paint. Prior to the start of the test, a 1-m swath on either side of each transect was completely cleared of all goose fecal deposits using a Little Wonder 8-hp blower (Little Wonder Company, Southampton, Pa.).

Fecal deposits were collected within 0.25 m of the center-line marks from the entire length of each transect. We collected goose fecal deposits every 2 days starting 5 to 7 days pretreatment and ending 28 days post-treatment. They were packaged, frozen, and shipped to the Denver Wildlife Research Center, where they were dried to a uniform moisture and weighed. We converted fecal deposit weights to g/transect-m by unit for each day of collection by using formulas appropriate for a stratified random sampling with sampling units of unequal size (Cochran 1977:316).

Observations of geese began 5–7 days pretreatment at each site and continued daily until 28 days post-treatment. Observations consisted of recording the number of birds in each unit at 5-minute intervals for 60 minutes between 0700 and 1200 hours. We collected data during the same 60-minute period at each site each day from locations that permitted unobstructed views of all units without disturbance of any geese present. We converted goose numbers to birds/unit for each pre- and post-treatment day.

To determine chemical stability under existing environmental conditions, we placed 500-g samples of DMA and MA starch in 30-cm diameter open glass containers near a test site and exposed the samples to environmental conditions. On days 1, 4, 7, 14, 21, and 28 post-treatment, 20-g of each sample were collected, bagged, labeled, frozen, and shipped to NSC for anal-

Table 2. Mean goose fecal deposits (g/transect m) on dimethyl anthranilate (DMA), methyl anthranilate (MA), and control sites by 6-day test periods during June and July 1988 near Basking Ridge, New Jersey. Mean values during the treated periods have been adjusted by the pretreatment covariate. *P* values correspond to the test of treatment equality from the ANOCOVA's, and SE is the standard error of the treatment mean.

Treatment	Pretreatment	Test period 1	2	3	4	5	Treatment period average
Control	5.1	5.6	5.4	5.9	10.7	7.5	7.0
(SE)	(1.1)	(0.6)	(1.5)	(1.1)	(2.1)	(2.6)	(1.1)
DMA	8.9	3.3	3.1	5.0	3.8	2.7	3.6
(SE)	(1.5)	(0.6)	(1.5)	(1.1)	(2.1)	(1.6)	(1.1)
MA	7.1	3.9	4.2	5.5	3.4	2.8	4.0
(SE)	(1.5)	(0.5)	(1.3)	(1.0)	(1.8)	(1.3)	(0.9)
P		0.113	0.641	0.881	0.088	0.129	0.133

ysis by gas chromatography (GS). Lack of acceptable analytical techniques precluded determination of DMA and MA residues on grass.

Bird numbers and goose fecal deposit weights collected during the pretreatment period were averaged for each experimental unit and used as covariates in analyses of covariance (ANOCOVA; described below). The set of 28 daily post-treatment bird observations on each experimental unit was divided into 4 periods of 7 consecutive days each, and observations within each period were averaged to create 4 post-treatment period responses. Similarly, the set of 14 post-treatment dropping collections for each experimental unit was divided into 5 periods containing 3 consecutive collections each (the last period contained only 2 collections). Collections within periods were averaged.

We conducted several ANOCOVA's using PROC GLM (SAS Inst. Inc. 1987) to test the null hypotheses of equal treatment effects among control, DMA-, and MA-treated experimental units for both mean bird numbers and feces weights. First, individual randomized block ANOCOVA's were conducted for each post-treatment period, using sites as random blocks, and treatment as a fixed factor. A 3-factor ANOCOVA was also performed, using sites as random blocks, treatments as a fixed factor, and period as a repeated measure. Significance level for ANOCOVA F-tests was set at 0.10. If this test was significant, then the Bonferroni (Games 1971) pairwise comparisons were used (P = 0.10) to isolate significant differences among means.

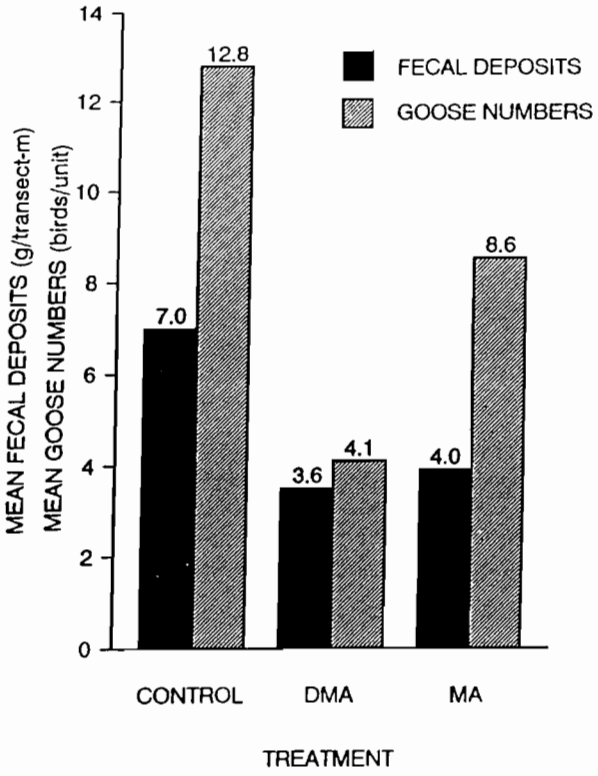

Fig. 2. Average fecal deposits (gm/transect-m) and goose numbers for sites treated with dimethyl anthranilate (DMA) and methyl anthranilate (MA), and for control sites during June and July 1988 near Basking Ridge, New Jersey.

RESULTS AND DISCUSSION

Goose Fecal Deposits

In every test period, control plots averaged the highest number of fecal deposits (Table 2). In all periods except period 4, DMA treated plots had the lowest amount of fecal deposits, and MA treated plots were slightly higher. However, only in period 4 did these differences achieve statistical significance (F = 3.51; 2,7 df; P = 0.088). Bonferroni comparisons revealed that DMA and MA means were significantly less than controls, and that DMA and MA did not differ. During the 28-day treatment period, mean goose fecal deposits per transect-m were 7.0 g on control units, 3.6 g and 4.0 g on DMA and MA units (Fig. 2). The 3-way repeated measures ANOCOVA indicated that these differences were not significant (F = 2.73; 2,7 df; P = 0.133). There was not strong evidence of a treatment by period interaction (F = 1.86; 8,28 df; P = 0.107), suggesting that treatment performance was relatively consistent among periods (Table 2). There was no evidence of differences in overall fecal deposits among periods (F = 0.99; 4,28 df; P = 0.429).

Use of the pretreatment mean fecal deposition as a covariate to adjust for a prior difference in bird usage was generally quite effective in increasing the sensitivity of the analysis. For example, mean squared error in the 3-way ANOCOVA was 44.7, compared to a value of 75.7 when the data were analyzed without the covariate.

Goose Numbers

Analysis of individual period results produced evidence of treatment differences only in period 4 (F = 4.15; 2,7 df; P = 0.065) (Table 3). Bonferroni pairwise comparisons revealed

Table 3. Mean goose numbers/unit observed on dimethyl anthranilate (DMA), methyl anthranilate (MA), and control sites during June and July 1988 near Basking Ridge, New Jersey. Mean values during the treatment periods have been adjusted by the pretreatment covariate. *P* values correspond to the test of treatment equality from the ANOCOVA's, and SE is the standard error of the treatment mean.

Treatment	Pretreatment	Treatment period				Treatment period average
		1	2	3	4	
Control	10.3	12.1	14.5	17.5	7.2	12.8
(SE)	(4.1)	(4.4)	(3.5)	(4.6)	(1.3)	(2.3)
DMA	12.7	6.3	3.6	4.7	2.0	4.1
(SE)	(2.9)	(4.7)	(3.7)	(4.9)	(1.4)	(2.5)
MA	5.3	10.2	11.8	6.6	5.7	8.6
(SE)	(1.8)	(4.9)	(3.8)	(5.1)	(1.4)	(2.5)
P		0.679	0.152	0.168	0.065	0.087

a difference only in goose use between DMA and control plots. Overall, mean goose numbers per unit were 12.8 birds on control units, and 4.1 and 8.6 birds on DMA and MA units, respectively (Fig. 2). The 3-way repeated measures ANOCOVA showed differences among these means ($F = 3.53$; 2,7 df; $P = 0.087$). Again, Bonferroni comparisons revealed a difference only between DMA and control means. Lack of any evidence of a period by treatment interaction ($F = 0.58$; 6,21 df; $P = 0.744$) suggested a consistent relationship in the performance of treatments among test periods in affecting bird numbers. Periods did not ($F = 0.29$; 3,21 df; $P = 0.834$) reveal any significant variation in overall average numbers of geese during the post-treatment period.

Average bird numbers during the pretreatment period also proved to be an effective covariate for increasing the precision of the analysis. Mean squared error in the 3-way ANOCOVA was 26.0, compared to a value of 44.8 in the same analysis run without the covariate.

Chemical Stability

Chemical concentrations in the starch matrix that were exposed to environmental conditions for 28 days decreased by 41% (DMA) and 47% (MA). The greatest loss (16%) for DMA occurred between days 3 to 7, whereas the greatest loss (19%) for MA occurred between days 7 to 14. Formulation samples taken from the spray tank prior to spraying at Allied and Summit showed that concentration levels of DMA and MA averaged about 1.4% (wt/wt) compared to the expected formulation concentration of 1.2%. Total precipitation recorded during the 28-day period was 2.1 cm except for the Summit site, which received about 0.6 cm of irrigation water a day (16.8 cm total). Rainfall and irrigation were probably not factors in chemical loss, but could have accelerated the natural breakdown of the starch matrix.

Large variations in estimated fecal deposits and goose numbers within units at a site suggested either that problems might exist with spraying, and/or chemical concentration, or that the compound was unable to produce consistent aversive responses by geese. The lack of a method to extract chemical residues from grass precluded comparative analyses of residue levels with goose fecal deposits and bird numbers. There is a possibility that DMA and MA either are being absorbed into grass or are being hydrolyzed (possibly into anthranilic acid). Hydrolysis is an especially troubling possibility because the less costly MA is less susceptible to reduction than the more complex DMA molecule. Differences in treatment effectiveness between these 2 anthranilate derivatives could be an artifact caused by their different hydrolysis rates rather than because

of differential sensitivity of geese to the 2 chemicals.

Starch matrix particles occasionally caused problems in the delivery systems. Several particles clogged spray nozzles, although increased pressure tended to alleviate this problem. Inspection of sprayed areas immediately after treatment revealed that large particles (>50 mesh) were not sticking to the grass, which could have contributed to reduced repellency.

MANAGEMENT IMPLICATIONS

We suggest that improvements in the encapsulation process and formulation might enhance the effectiveness of DMA and MA. Two areas of consideration would be a time release capsule and a pressure release capsule. Pressure release capsules would have the distinct advantage of having to be broken before release of chemical would occur. Thus, the effectiveness of the treatment could be prolonged on turf.

Since the cost difference between DMA ($35/kg) and MA ($7/kg) is substantial, there would be a distinct economical advantage of developing MA as a goose grazing repellent. With modifications in the encapsulation process, increased application rates, or both, the cost of an MA application would be lower than the acceptable cost of $60/ha that turf managers are willing to spend on a goose grazing repellent (Otis, unpubl. data). MA could possibly become a cost-effective repellent with improvement in the encapsulation process. Further evaluations of alternative encapsulation methods are planned.

SUMMARY

We examined the repellent effects of dimethyl anthranilate (DMA) and methyl anthranilate (MA) applied at a 3.4 kg/ha (A.I.) rate to 5 grassy areas in New Jersey frequented by Canada geese (*Branta canadensis*) during June and July 1988. Results showed that control plots averaged the highest number of fecal deposits; however, only in period 4 (days 22–28 post-treatment) did these differences achieve statistical significance. During the 28-day treatment period, mean goose fecal deposits per transect-m (7.0 g on control units, 3.6 g and 4.0 g on DMA and MA units, respectively) did not differ. Analysis of goose numbers by period produced evidence of treatment differences only in period 4. Overall, mean goose numbers per unit (12.8, 4.1, and 8.6 birds on control, DMA, and MA units, respectively) differed among treatments. Chemical concentrations in formulated samples exposed to environmental conditions showed a 41% and 47% loss of chemical after 28 days for DMA and MA, respectively.

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